WAR MEDICINE

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THE TACHYCARDIAS OF SOLDIERS.

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In the present war it has been the experience of the European combatants that many men have broken down during the stress of active campaigning as a result of damaged or insufficient hearts which were unable to bear the additional strain thrown upon them by the campaign. Many of these heart cases were invalided home on account of frank cardiac disease, valvular disease unrecognized through insufficient examination at the time of the physical examination upon entering the army or myocardial disorders unsuspected or developing after entry into the army. There were, however, many returned to home hospitals in whom actual organic cardiac disease could not be demonstrated, yet who suffered from a group of symptoms which were for the most part almost entirely referable to the cardiovascular apparatus and to which various terms have been applied, suggestive of the part played by the heart in producing and maintaining these symptoms. This symptom-complex is referred to by the English as "disordered action of the heart (D. A. H.)," as the "irritable heart of the soldier," as "soldier's heart" and as "effort syndrome." The terms are very inclusive, and practically any case with subjective cardiac symptoms, no matter what the cause, sufficiently severe to prevent the man carrying on his duties as a soldier, is listed as D. A. H., provided that the objective symptoms are not sufficiently marked to enable the physician to label the disorder as a definite nosological entity. As a result of this rather indiscriminate filing of indefinite cases into the one cabinet there is considerable confusion in the English and French literature as to just what is "soldier's heart." Certainly there is decided confusion as to the pathogenesis of the condition and as to what cases should be included etiologically. Most observers are, however, united in describing the same group of symptoms for the condition, but are divided, necessarily, owing to the obscurity of the etiology, upon the question of proper treatment and the management of these cases.

There is one outstanding and notable symptom not only in organic cardiac disease but also in disordered heart action cases, and that is rapidity of the pulse. It is almost a *sine qua non* for the diagnosis of these latter cases. Because of this and because of the ease with which it is appreciated in physical examination it is an extremely important symptom, but unfortunately one which may be interpreted in many ways. A rapid pulse is only a symptom, and it may be indicative of an infection, of disordered nervous mechanism or of a disturbance of the endocrine system as well as pointing to the heart itself.

On account of the large number of soldiers with tachycardia that were referred for opinion during the course of the cardiovascular examinations of the 38th Division at Camp Shelby, it was thought advisable to devise a working classification for these cases in order to attempt to classify them, with the idea that these sufferers with tachycardia could be grouped into one of several etiological classes and that the subsequent course in the army of these men could be followed from the stand-point of their ability to carry on their duties as a soldier. The latter part of this paper will deal with the classification that was used during the examination. In the first portion of the article will be discussed the English and French experiences with soldiers suffering with tachycardia, and more especially "disordered action of the heart" or "soldier's heart."

SOLDIER'S HEART.

The recognition of this syndrome by no means is original to the present war, but was first described by Dr. Henry Hartshorne,[1] to be followed several years later by the classical paper of J. C. Da Costa,[2] who describes the symptom-complex most accurately; in fact, his description tallies closely with the present-day picture of the disorder. In the succeeding years there has been more or less written about "soldier's heart," and none of it of much value. Although war broke out in 1914, the first reference to the condition is in an article by Magnus-Levy,[3] who notes the frequency with which the wounded complain of dyspnea, precordial pain and palpitation, and with which they show a tachycardia, poor response to exercise, increase in the area of cardiac dulness and systolic murmurs. This article was followed by many others in the German literature. In English literature the earliest reference to the condition is in an editorial of the *British Medical Journal*, July 17, 1915. In November, Thomas Cotton, Thomas Lewis and F. H. Thiele[4] published a short note on the occurrence of bacteria in the urine of sufferers with irritable heart. Succeeding this article has come forth a veritable stream of articles on the subject, culminating in the splendid, thorough, comprehensive and scholarly study of Thomas Lewis and his co-workers working under the auspices of the Medical Research Committee.[5] In this monograph all the various phases of the subject are considered in detail and a large amout of clinical and experimental work incorporated, so that one interested in the subject will find there an extremely complete discussion of the etiology, symptomatology, pathology, prognosis and treatment of soldier's heart.

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[1] On Heart Disease in the Army, Tr. Coll. Phys., Philadelphia, AM. JOUR. MED. SC., 1864, xlviii, 89.

[2] On Irritable Heart. A Clinical Study of a Form of Functional Cardiac Disorder and its Consequences, AM. JOUR. MED. SC., 1871, lxi, 17.

It will be advisable to digest in brief this report and to incorporate the opinion of others upon these subjects.

DEFINITION. Major Meakins,[6] Lewis and their associates give the following definition of "irritable heart of soldiers:" "We use it (the term irritable heart) to describe those patients in whom few or none of the graver signs of heart affection can be detected but in whom there is complaint of breathlessness, palpitation, giddiness or actual fainting, easy exhaustion and precordial pain in varying degree, symptoms arising for the most part under exertion or exaggerated by it."

In later publications Lewis prefers to use the term "effort syndrome," believing that it is unwise to label this group of symptoms with a term which suggests to the soldier and to others that the heart is primarily at fault.

A somewhat more comprehensive definition of soldier's heart than the one recorded above might be given. A syndrome of symptoms referable for the most part to the heart, induced by too strenuous preliminary training or the mental and physical stress of actual warfare appearing in those soldiers who have suffered a recent infection and predisposed to by various factors of varying value, such as previous sedentary life, larval hyperthyroidism, indetectable myocardial disease or congenital myocardial insufficiency, unstable nervous system, subject to neuroses of different types, and excessive smoking (?)

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[3] Berl. klin. Wchnschr., January 11, 1915.

[4] A Note on the Irritable Heart of Soldiers, British Med. Jour., November 13, 1915, p. 722.

[5] Report upon Soldiers Returned as Cases of Disordered Action of the Heart (D. A. H.) or Valvular Disease of the Heart (V. D. H.), 1917. London: Causton & Sons.

[6] A Memorandum upon Heart Affections in Soldiers, British Med. Jour., September 23, 1916, p. 418.

ETIOLOGY. *Previous Occupation.* In Lewis's series of 543 cases 57 per cent. were engaged in sedentary occupations, 20 per cent. in moderately severe physical occupations and 23 per cent. in hard manual labor before entering the service. It is noteworthy that those used to hard physical work make the most satisfactory recovery.

Infection. Lewis lays particular stress upon infection as the most important etiological factor. In from 50 to 60 per cent. of his cases infection played an important role. It was during the convalescence from an acute infection that the symptoms first appeared in the greatest number of cases. Others had suffered previously from some acute infectious disease of marked severity, as pneumonia, rheumatism, typhoid fever. John Parkman[7] in a series of 40 cases found in 12 patients a previous history of an infection which may have been the exciting cause of the condition. Seven said they had had scarlet fever in childhood and 5 developed symptoms immediately following an illness in military service. Sir James Mackenzie[8] says that in the examination of about 400 cases of soldier's heart he has attributed the majority of these cases to bacterial and toxic influences. R. McN. Wilson[9] is in complete accord with Mackenzie, and L. Gallavardin[10] agrees that infections have a very decided influence upon the development and exaggeration of nervous tachycardias.

Shock. This was an immediate cause in only 2 per cent. of Lewis's cases, shock in all likelihood acting as a remote cause on a condition already existing.

Wounds and Other Accidents. These factors were present in 5 per cent. of Lewis's series. As in shock these accidents probably act much the same way. Added to this there is the added factor that most wounds are associated with infection.

Poisoning by Gas. This cause instituted the onset of symptoms in 3 per cent. of the Hampstead Hospital cases. Price and Hunt have called attention to the fact that certain gases may induce the syndrome either as a result of the action of the gas on the nervous system or else as a result of the febrile pulmonary complications of gas poisoning.

Sudden Overstrain. The occurrence of this factor was relatively rare, less than 1 per cent., in causing the onset of symptoms. A. Abrahams[11] is not in accordance with this view, he believing that this is responsible, in a fairly large number of cases, for the complex.

SYMPTOMATOLOGY. Mackenzie's[12] description of the onset of symptoms deserves to be quoted: "The account given of the onset of the symptoms is peculiarly instructive. They will say they were in the trenches and felt well and fit until one day they felt seedy and ill, and this continued until they were compelled to seek medical advice, when they were found to have a raised temperature. A few days' relief was obtained and they returned to their work still feeling far from well, and after a few weeks of the strenuous life in the trenches they collapsed, sometimes with loss of consciousness, breathlessness or even pain.

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[7] The Cardiac Disabilities of Soldiers on Active Service, Lancet, London, July 22, 1916, p. 133.

[8] The Soldier's Heart, British Med. Jour., January 22, 1916, p. 117.

[9] The Irritable Heart of Soldiers, British Med. Jour., January 22, 1916, p. 119.

[10] Les tachycardiques, Arch. de mal de coeur, September, 1917, p. 408.

[11] Soldier's Heart, Lancet, London, March 24, 1917, p. 442.

[12] Loc. cit.

"The story of the onset varies. Sometimes it is an attack of diarrhea, which persists for a time; sometimes it is after a definite illness, as measles, but most give a history which we can safely surmise as being due to an infection. In a few cases one cannot get such a definite account of the starting of the illness, but many do recognize the gradual onset of the trouble. That is the story of the majority of cases, but there are a number from whom we can get no suspicious history of infection but in which there is an account of a very strenuous life."

Symptoms in Detail. Practically all observers are united in describing the same subjective and objective manifestations of the disorder, but the Research Committee's report by Lewis is so complete that it will suffice to secure a complete picture of the condition to abstract it and use it as the basis for the description of the symptomatology.

Dyspnea. This is complained of by all patients after effort; when quiet the patient does not notice it except in an occasional case of nervous, rapid breathing, but slight effort brings this out so that the respirations are increased moderately, while more severe effort will cause a rise of respiratory rate to 60 to 70 per minute.

Lewis,[13] in discussing the cause of breathlessness in patients suffering from irritable heart, expresses the opinion that it is due to the inadequate supply of buffer salts in the blood. He shows that he and his co-workers have demonstrated this, and calls attention to the fact that this symptom of breathlessness arises as a result of disordered metabolism, though the commonly accepted cause of breathlessness has been held to be instability or irritability of the central nervous system. This inadequate supply of buffer salts permits overstimulation of the respiratory center by the CO_2 developing as a result of exercise. There is an insufficiency of these salts, consequently their buffer effect is lost and the CO_2 is able to act more directly upon the center than if these salts were present to neutralize and to overcome the direct shock of the acid CO_2 upon the center.

Pain. This is another very constant symptom, occurring in over three-quarters of all cases. The pain is of different degrees, varying from slight precordial distress to severe pain over the entire precordium and transmitted down the left arm. The pain is induced by exercise. J. C. Meakins and E. B. Gunson[14] have shown that in 48 per cent. of soldiers with irritable hearts, complaining of severe pain, there is nearly always present an area of hyperalgesia over the left chest in front. This hyperalgesia is similar to that seen in cases of angina pectoris; it is increased by exertion; infection increases the precordial pain and hyperalgesia; and the presence of precordial hyperalgesia is indicative of severe cases, with poor prognosis.

Palpitation. This is also a very common symptom. In the great majority of cases it is due solely to the increased rate of the heart after exercise and disappears as soon as the heart rate slows down. Occasionally palpitation is due to extrasystoles which appear during rest to disappear during exercise.

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[13] Breathlessness in Soldiers Suffering from Irritable Heart, British Med. Jour., October 14, 1916, p. 517.

[14] The Occurrence of Hyperalgesia in the Irritable Heart of Soldiers, Heart 1917, vi, 343.

Cerebral Symptoms. Vertigo occurred in about 75 per cent. of the patients. The patients were dizzy after exertion, the dizziness being accompanied by spots of light in the visual field. It was always pronounced when changing from prone to upright position quickly. This probably induced a sudden fall in intracranial pressure, though it is not always possible to show a fall; indeed, a rise in peripheral systolic pressure is seen at times.

Syncopal attacks were found to occur in six subjects. The pulse rate was slowed, though attacks did not altogether resemble those found in Adams-Stokes's disease, and the systolic blood-pressure was likewise much lowered.

Sweating and Salivation. The subjects of soldier's heart were found at rest to have moist sweating hands, and during the physical examination, sweat would run down from the axillary sweat glands. Physically effort would induce sweating out of all proportion to the degree of exercise as would a stimulation of the emotions. An increased amount of saliva was also thought to be secreted. T. F. Cotton, J. G. Slade and Thomas Lewis[15] conclude, from a series of studies upon these men after injections of pilocarpin nitrate, that "the increased activity of the sweat glands and the increased activity of the salivary glands (as estimated by the rate of swallowing) of patients suffering from "irritable heart" appear to be due to hyperexcitability of the corresponding peripheral mechanisms."

Vasomotor Symptoms. Spontaneous flushing is induced by the slightest cause. Cotton, Slade and Lewis[16] say, as a result of their studies with amyl nitrite, that this spontaneous flushing is "conditioned more often by the state of the peripheral vessels than by hyperirritability of the nervous system."

Pulse Rate. The increase of the pulse rate upon effort is one of the most characteristic symptoms found by Lewis and his co-workers. Furthermore, it is an extremely valuable objective finding in cases which may have complaints suggestive of the disorder but in whom these complaints might be due to other causes. Slow recovery of the pulse rate to what it was before exercise is a bad prognostic sign, though quick recovery is not necessarily a sign that ultimate fitness will be attained by proper treatment. J. C. Meakins and E. B. Gunson[17] show that before the simple test exercise (walk 75 paces at quick time ending in a climb of 27 steps) the average pulse rate was 86 per minute (controls 75), the rise after exercise 131 (control 110), the length of time of the return of the pulse rate to normal was in direct ratio to the severity of the symptoms. They also found that rest in bed and intercurrent acute infections have a most deleterious effect upon the return of the pulse rate to normal after exercise. John Parkman[18] found that after slight exertion and on standing the average increase in pulse rate was greater in these patients than in the controls.

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[15] Observations upon Pilocarpin Nitrate, Heart, 1915–17, vi, 299.

[16] Observations upon Amyl Nitrite, Heart, 1915–17, vi, 311.

[17] The Pulse Rate after a Simple Test Exercise in Cases of Irritable Heart, Heart, 1915–17, vi, 285.

[18] The Pulse Rate on Standing and on Slight Exertion in Healthy Men and in Cases of Soldier's Heart, Heart, 1915–17, vi, 319.

Blood-pressure. The blood-pressure at rest is usually about normal. The effect of a fixed amount of exercise upon blood-pressure shows that the reaction is qualitatively the same, but the pressure rises higher and the raised pressure is longer sustained in the patients than in controls.[19]

Effect of Drugs. Digitalis, according to J. Parkman,[20] has scarcely any influence in this condition and is not indicated. Adrenalin, a sympathetic stimulator, was found to have a greater effect upon the heart sympathetic than in the normal, while apocodein, a sympathetic depressor, caused similarly a greater depression.

The Physical Examination. Aside from the pulse rate, physical examination seems to disclose but little in these cases. In fact, the absence of physical signs is one of the negative symptoms of value. In the Hampstead Hospital Report, Lewis goes into the question of systolic murmurs with considerable thoroughness. He shows that systolic murmurs *per se* have but little importance. Two hundred and sixty-six soldiers did not show any murmurs, and of these 58 per cent. were definitely unable to be restored to duty, while of 196 soldiers with systolic murmurs only 51 per cent. were unfit for duty. Meakins, Lewis and others[21] say that "A systolic murmur at the apex is not considered to be a sufficient ground for discharge, whatever the character of the murmur; in our experience many men who present this sign are capable of a great deal, if not of full and continued effort."

In these sentiments the authors are in accord with Sir James Mackenzie, who holds that the functional capacity of the heart is the criterion upon which hearts must be judged, not the presence or absence of murmurs. This view-point of Mackenzie, long held by him, but brought to the fore by his advice to medical examiners not to reject men with heart murmurs unless their hearts showed definite signs of insufficiency or gross myocardial change, precipitated an active and at times even acrimonious debate among English cardiologists and clinicians. The work of Lewis would seem to support Mackenzie's contention most completely, though the controversy still is active in English periodicals.

The Apex Beat. Extension of the apex beat downward only shows that there is hypertrophy of the heart and does not help in determining the functional capacity of the organ. Likewise the force of the beat, its definite localization or diffuseness has no value in making the above determination.

The Size of the Heart. The report of the Medical Research Committee contains some interesting roentgenological observations by Meakins and Gunson upon the change in the size of the heart after exercise. In the normal individual active exercise results in a diminution in the diameter of the heart of about 1 cm. In patients whom the exercise caused the usual symptoms a decrease in the diameter of the heart was not noted, nor was there, however, any increase in size of the transverse diameter or dilatation, though the absence of the usual and normal diminution in size might be construed as a dilatation.

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[19] T. Cotton, D. L. Rapport and Thomas Lewis: After-effects of Exercise on Pulse Rate and Systolic Blood-pressure in Cases of Irritable Heart, Heart, 1915–17, vi, 269.

[20] Digitalis in Soldiers, with Cardiac Symptoms and a Frequent Pulse, Heart, 1915–17, vi, 321.

[21] Loc. cit.

Electrocardiographic Studies. These showed no variations other than occur in certain normal individuals. The tracings are of no value in diagnosis nor in prognosis.

Leukocytosis. One of the most valuable objective signs of the presence of soldier's heart is found in the leukocyte count. G. Briscoe[22] found that in cases of irritable heart there was a constant leukocytosis when the patient was up and about and increased by exercise. She found that this was slight or there was none at all during absolute rest. The degree of leukocytosis seemed to be in direct relation to the severity of the case. Thus in the 4 most severe cases clinically the counts after exercise varied between 18,000 to 23,000 as contrasted with the 4 least severe cases which showed after exercise a moderate increase, 8700 to 13,700. The rise after exercise is in all cases greater than in normal controls.

In regard to the differential count she noted a higher lymphocytic count in cases of long standing, though the highest values were obtained in a case of only six weeks' duration. The percentage rise in lymphocytes may be marked in patients who show only a slight leukocytic increase after exercise. Furthermore, the variability of the several kinds of leukocytes is greater than in normal individuals. The author also calls attention to the fact that while the leukocytosis is of value in diagnosis, being uncontrolled by the patient, in prognosis it is of not much assistance, as the condition of the blood varies with the general condition of the patient, which can be judged by the usual clinical methods.

Urine. The total quantity is usually reduced. In 60 per cent. of the cases the acidity was greatly increased. In general, amino-acids, calcium and oxalic acid are increased; phosphates and urea decreased; uric acid, creatinin, sulphates normal.

It has been suggested that the amino-acid increase might be correlated with the urea decrease as an indication of functional liver trouble.

The urinary acidity in normal controls is unchanged after exercise to increase slightly one to one and a half hours afterward, while in these subjects of soldier's heart the acidity falls after exercise to increase very much more than the normal controls in an hour to an hour and a half.

PROGNOSIS. While the present article is concerned chiefly with the symptoms and the causative factors of this condition it might be well to briefly consider Lewis's figures as to ultimate serviceability of these men: 63 per cent. of the men coming from training camps are definitely unsuitable to carry on their full duties as soldiers and but 48 per cent. when they come from active service; 64 per cent. of those who had symptoms before enlisting are unsuitable for future service; 48 per cent. are unsuitable whose first symptoms appeared at time of training and 40 per cent. whose symptoms appeared during active service. Among those who performed manual labor before entering the service, 48 per cent. and those who led a previous sedentary life 53 per cent. were unsuitable to be returned to duty. Lewis also says that the symptoms existed in 43 per cent. before enlistment, 12 per cent. developed them during the training period and 45 per cent. during active service.

TREATMENT. Detailed treatment will not be considered. Suffice it is to say that rest in bed is distinctly countra-indicated. Gradually increasing exercise has given the best results to all observers, though A. E. Garrod[23] has called attention to a group of cases in which the myocardium is involved as a result of some fresh or recent infection and in whom exercise is counra-indicated and rest in bed indicated.

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[22] The Leukocytes in Cases of Irritable Heart, Lancet, London, June 2, 1917, p. 832.

Pathogenesis. The pathogenesis of soldier's heart has aroused so much discussion in England, as already mentioned in the forepart of this paper, that it may be well to discuss the various hypotheses advanced to explain the condition.

I. *Blood Infection.* As recounted earlier in this paper Cotton, Lewis and Dale[24] aroused interest in the possible infectious origin of soldier's heart by describing the occurrence of an almost constant bacilluria in these cases and at times bacillemia. Subsequent work failed to confirm this, and G. Briscoe and L. Demoud[25] put at rest this theory by making 96 observations on 43 cases of irritable heart at the Hampstead Military Hospital, none of the cultures proving positive when a careful technic was evolved.

II. *Overstrain of Heart.* That sudden severe or continuous overstrain of the heart may occasion soldier's heart is a possibility in rare cases, but in the majority of cases surely there is no such possibility. Sir Clifford Allbutt[26] says that "heart strain," a phrase at one time, a few years ago, in common use, is a rare event and does not constitute the bulk of the cases invalided home as D. A. H. Thomas Lewis[27] says that the condition originated in sudden effort in only 5 cases that he had seen. Effort aggravates the symptoms and displays defects which are latent, but that it is responsible for the condition is not to be believed from present evidence. The strongest evidence of damage by strain must be forthcoming before it can be believed that so vital a muscle as the healthy heart can be injured by strain. Sir James Mackenzie says that "I never saw a single individual who suffered from heart dilatation as a result of overexertion. I think I may fairly say that this was not due to inability to recognize overstrain." In this article, in which Captain A. Abrahams[28] quotes Mackenzie, he (Abrahams) says that he has never seen a case of overstrain in the examination of many athletes' hearts. Captain J. Parkinson[29] says that among his 40 cases only 4 attributed the onset of symptoms to a particular exertion, and 3 of these cases had had recent influenza. Contrary opinions as to the likelihood of strain causing symptoms of cardiac insufficiency are held by others. Captain W. Scarisbrick[30] in his paper on the comparative incidence of heart disease among soldiers and recruits finds 26.6 per cent. of the former and 15.2 per cent. of the latter suffering with "strained hearts." Dr. I. Mackenzie,[31] however, believes that there is no evidence to show that in cases of soldier's heart the disease has resulted from strain of a physical character. In work done before the war, Moritz, de la Camp, Selig and many other German observers claim that the heart cannot dilate under the influence of muscular tension.

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[23] A Variety of War Heart which Calls for Treatment by Complete Rest, Lancet, London, June 30, 1917, p. 985.

[24] Loc. cit.

[25] Bacteriological Examination of the Blood in Cases of Irritable Heart, British Med. Jour., August 18, 1917, p. 210.

[26] The Investigation of the Significance of Disorders and Diseases of the Heart in Soldiers, British Med. Jour., August 4, 1917, p. 139.

[27] Soldier's Heart, Lancet, London, March 31, 1917, p. 510.

[28] Ibid., March 24, 1917, p. 442.

[29] Loc. cit.

[30] Cardiac Disease in Soldiers and Recruits, British Med. Jour., February 24, 1917, p. 254.

[31] The Soldier's Heart, Glasgow Med. Jour., 1916, lxxxvi, 213.

III. *Hyperthyroidism.* The hypothesis that the overaction of the heart is due to oversecretion of the thyroid gland is one that appeals to many observers of the condition, nor is this view-point a surprising one when the marked similarity of the symptoms of early Graves's disease to those of the irritable heart of the soldier is considered. One of the foremost advocates of this theory in part is Dr. J. Strickland Goodall,[32] who states in his Chadwick Lecture, based on 2250 cases of soldier's heart, that many cases of soldier's heart are due to the temporary overaction of the suprarenal glands as a result of fright, with a resulting overaction of the thyroid to neutralize this stimulation of the suprarenals. The thyroid overaction persists, the suprarenals overaction is but temporary. Captain Scarisbrick[33] says that in some of his cases hyperthyroidism accounted for the cardiac neuroses. H. J. Leeuwen,[34] working under Major Tait McKenzie, found the thyroid enlarged in about 25 per cent. of his cases, and states that some of his cases suffered from hyperthyroidism. Wilson,[35] Sir James Mackenzie's assistant, says that while the theorists are bankrupt the disease remains. In 18 of his cases, however, he was interested in observing that the thyroid was enlarged and administration of thyroid caused exacerbation of the symptoms. Sir James Barr[36] says that it is no wonder that, under present conditions of war, we should get great vascular disturbance and increased function of the thyroid gland. He says that all these cases of soldier's heart depend upon an increase or decrease of the internal secretion of the thyroid and that the proper treatment in these cases is that used in the treatment of hyperthyroidism or hypothyroidism. This paper of Barr's provoked considerable discussion in the literature, pro and con, as to whether the thyroid was necessarily at fault in all cases. Dr. F. A. Stoney,[37] working at the Fulham Military Hospital, believes that there is a very close relation between hyperactivity of the thyroid gland and the tachycardia and breathlessness seen in cases of irritable heart. In addition to the rapid pulse and breathlessness, together with the sinus arrhythmia and apical systolic murmurs, there is also noted tremor, insomnia, enlargement of one or both lobes of the thyroid and, more rarely, ocular symptoms. She believes likewise that a cure may be effected by securing partial atrophy of the thyroid gland with the roentgen rays. C. P. White and F. Hernaman-Johnson[38] also contend that hyperthyroidism is the cause of soldier's heart and treatment by the roentgen rays should not be neglected.

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[32] The Factors of Cardiac Irritability, Lancet, London, June 23, 1917, p. 962.

[33] Loc. cit.

[34] The Heart and Active Service, Lancet, London, September 2, 1916, p. 432.

[35] Irritable Heart of Soldiers, British Med. Jour., January 27, 1916, p. 119.

[36] The Soldier's Heart and its Relation to Thyroidism, British Med. Jour., April 15, 1916, p. 544.

[37] On the Connection between Soldier's Heart and Hyperthyroidism, Lancet, London, April 8, 1916, p. 777.

[38] Hyperthyroidism as a Cause of the Irritable Heart of the Soldier, Lancet, London, January 8, 1916, p. 78.

Among the French, Gallavardin[39] also believes that in some cases the thyroid may be at fault, though this explains only some of the cases. D. Pletnew,[40] on the contrary, says that he has almost never seen it. Lewis[41] summarizes the opinions against incriminating the thyroid as follows: In spite of the frequency with which the thyroid is said to be enlarged by advocates of the hyperthyroid hypothesis, in his series of cases only 4 per cent. showed this sign; the symptoms of tachycardia, tremor and so on are seen after infectious diseases, and the thyroid is not asked to explain them; roentgenotherapy gives too doubtful results to be good evidence; and finally thyroid extract given experimentally seems to have no more effect on these cases than on other unrelated cases.

IV. *Disturbance of Nervous System.* All authors agree that the nervous element plays a more or less important part as an excitant of the disorder. Mental stress is if not a greater at least an equal factor with physical stress in exciting the attack. Some writers claim it is the entire and sole cause. For example, Dr. I. Mackenzie[42] says that the soldier's heart in all probability belongs to the disorders of psychic origin. Tullidge[43] also calls attention to the psychic origin of the neuroses. R. D. Rudolf[44] says that "the condition is in reality part of a general nervous instability—in other words, neurasthenia." Dr. Poynton[45] believes that nerve shock is a factor of importance in some cases. Alexander Morrison,[46] in discussing the question as to the pathogenesis of the condition, says that in his belief the condition is one of neurasthenia or psychasthenia. Sir William Evart[47] holds that the heart may collapse as a result of gradual exhaustion of the myocardium, myocardial failure or as a result of some overwhelming shock in a nerve-worn subject, functional heart stroke, and that "soldier's heart" is probably a combination of these two factors.

Lewis discusses the hypothesis of the nervous system causing the condition in brief as follows: In general the subjects of cardiac irritability are emotional, high-strung individuals with exaggerated reflexes. Vagal tone is not abolished, as experiments with atropin show, but that the vagus action is normal is questionable because the pulse fails to return to normal after exercise, because sinus (vagal) arrhythmia is often exaggerated in many cases and because syncopal attacks with extreme slowness of heart occur in some cases. On the other hand, lack of vagal tone does not appear to be responsible in irritable hearts, for the high pulse rate or the exaggerated response to exercise, rather a hyperirritability of some portion of the system which includes the acceleration reflex arc and the rhythm-producing center itself. Experiments with adrenalin and apocodein show that the sympathetic system is more easily stimulated or depressed than normal in those individuals suffering with irritable hearts. In all probability these variations in nervous excitability are secondary to changes in cellular metabolism or to true intoxications.

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[39] Loc. cit.

[40] Insufficance cardiovasculaire . . . . de la guerre, Arch. de mal de coeur, 1916, ix, 333.

[41] Loc. cit.

[42] Loc. cit.

[43] The Heart of the Recruit and the Soldier, Military Surgeon, 1917, xl, 24.

[44] The Irritable Heart of Soldiers, Canadian Med. Jour., 1916, vi, 796.

[45] British Med. Jour., January 22, 1916, p. 130.

[46] Ibid., 1911, p. 184.

[47] The Soldier's Heart and the Strained Heart, British Med. Jour., February 5, 1916, p. 218.

V. *Myocardial Lesions.* At the Hampstead Hospital it is the custom to sift out all cases of frank valvular and of myocardial diseases, referred there as D. A. H., before listing the remaining cases as having irritable hearts. In spite of this many of the cases of the irritable heart of soldiers gave a history of previous rheumatism or chorea, suggesting that mild myocardial lesions may give rise to the symptoms. Autopsy alone would be able to verify this. The electrocardiogram was unable to show any such evidence of myocardial disease in 10 cases examined by Parkinson. It does seem, however, hard to conceive of acute rheumatic fever leaving the heart muscle untouched, and it would seem that in these cases at least the myocardium was involved. Parkinson[48] in his study of 40 cases of soldier's heart excluded frankly diseased hearts. He believes that the relative cardiac insufficiency may be a sequel to certain acute infections, may be the result of myocardial changes due to age, may be associated with functional nervous disorders and may be due to endowment with a heart of limited efficiency. Garrod[49] calls attention to the fact, also, that there are certain cases of soldier's heart, following immediately after acute infections, in whom "the myocardium is damaged for a time." He concludes his article by saying that "the soldier's heart is not a clinical entity but includes a variety of morbid states."

Another phase of the question of the heart itself may be here considered, that is, the heart that is distorted in position or hypoplastic. Goodall[50] says that hearts showing persistent overexcitability of muscle or nerve are too horizontal in position because they are too soft. This lack of tone may be the result of impaired nervous control, habitual overwork with insufficient rest, or disuse, insufficient use or misuse. D. Pletnew,[51] in concluding his article on cardiovascular insufficiency in the war, says that the greatest number of soldiers who present the phenomena of cardiovascular insufficiency are individuals in whom early arteriosclerosis is appearing or whose heart and aorta are hypoplastic. In addition to insufficient development of these organs the disharmonious development of the different organs, plays an important part in the pathogenesis of insufficient heart. This latter develops most frequently among well-built men who have not been accustomed to muscular exercise. It might be added here that many of the English authors also call attention to the necessity of starting military training with mild exercise gradually increased.

VI. *Toxemia.* The hypothesis that a toxemia is the agent responsible for the disorder is the one accepted by Lewis as seemingly the most feasible. Receiving as it does the approval of Mackenzie[52] and Allbutt, as well as Lewis and his co-workers, who have studied the question so carefully from all angles, it is needless to state the hypothesis that is most generally accepted both in England and France.

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[48] Loc. cit.

[49] A Variety of War Heart, Lancet, London, June 30, 1917, p. 984.

[50] Loc. cit.

[51] Loc. cit.

[52] The Soldier's Heart, British Med. Jour., January 22, 1916, p. 117.

This hypothesis is based on the following facts: Most of the cases started from some infection; the symptoms are analogous to those appearing in convalescence from acute infections or in the early stages of pulmonary tuberculosis; the changes of the urine and of the blood, mentioned in the forepart of this paper, suggest an infection. This hypothesis assumes either the production of true toxic bodies acting on the heart or disorders of cellular metabolism resulting from the infectious process.

In closing this discussion of irritable heart it might be appropriate to insert here, while considering the toxic hypothesis, some remarks Sir Clifford Allbutt[53] made upon the researches of Dr. Lewis and his associates at Hampstead Hospital: "Setting aside for the while poisoning of the myocardium, may incidental infections produce any other effects in which the heart is concerned? The answer appears to be in the affirmative. These researches seem to discover a new disease, or rather to discriminate more exactly the features and nature of a disease less clearly apprehended already, by Da Costa and others as soldier's heart; or by those of us who have written upon neurasthenia as cardiac neurasthenia. The disease is one which is not uncommon in the civil population, but under the stress of the soldiers' training and among the aggregations of men in modern armies, it is more conspicuous and inconvenient."

Classification of Tachycardias Used in Examination of the Soldiers of the Thirty-eighth Division. Before discussing the classification of the large number of cases of tachycardia seen during the course of the cardiovascular examination at Camp Shelby, it may be well to sketch briefly the method of procedure in making the cardiovascular examinations. The cardiovascular examiner worked in conjunction with the tuberculosis board which examined practically every man in the command. The several members of this board in examining the thorax would percuss and auscult the heart at the same time they were going over the lungs. Any abnormality that they might detect in the heart, such as abnormalities in the cardiac impulse, excessive rapidity or slowness, murmurs, irregularity, accentuations and enlargements, was sufficient to refer the individual with the abnormal condition to the cardiovascular examiner. When a man was referred for cardiovascular examination a note was sent with him stating for what reasons he was referred. The examiner working alone in a separate room of the regimental infirmary then went over the soldier carefully and studied the condition thoroughly in order to determine the effect that it might have upon the soldier under the stress of active campaigning.

In addition to the usual methods of physical examination the functional strength of the heart was estimated by having the examinee hop seventy times on one foot. The pulse was counted before the hopping test, immediately afterward and two minutes later. A return of the heart rate preceding exercise, provided that immediately following exercise there was an increase in rate, was considered evidence of good functional capacity of the organ. In reference to this exercise test of functional sufficiency of the heart, which is recommended by the

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[53] Loc. cit.

Surgeon-General's Office and which is generally considered the best test of cardiac sufficiency, it might be well to quote Meakins, Lewis and others.[54] "It has been our special endeavor to find some relatively simple and quick test which will eliminate the unfit, and for this purpose we have made elaborate observations upon pulse rate, blood-pressure and respiratory rate under various conditions of posture and exercise. We have taken numerous instrumental records, polygraphic and electrocardiographic; we have also noted such physical signs as basal murmurs, jerky impulse, extended impulse, various alterations of the heart sounds and signs of vasomotor instability; with a solitary exception we find these to be of no value in gauging the grade of exercise which will be ultimately tolerated or readily be borne. The solitary exception is the rate at which the pulse falls when it is accelerated by a brief exercise." C. Lian,[55] in France, is also an advocate of this method of testing the functional efficiency of the heart while in this country. T. B. Barringer, Jr.,[56] has done a great deal of work upon this same principle.

Nine hundred and forty-four soldiers, from the division of a strength of 22,622 at the time of the examination, were sent for special study of the cardiac condition. Of those thus referred, 424 (44.9 per cent.) were sent with the diagnosis of "tachycardia." It is thus seen that a very large number of the cases studied were cases of a rapid heart action. In fact, the provisional diagnosis of tachycardia exceeded by a large number any other single diagnosis. The heart rate was determined by counting the number of systoles heard by the stethoscope over the precordium in thirty seconds. The cardiovascular examiner was authorized by the Surgeon-General to act upon these cases in three ways, either unconditionally to "reject" or to "accept" the examinee as a soldier, or to "accept conditionally," with the idea that a future examination would show if the condition had so improved under training that the man could carry on the duties of a soldier.

In the study of the 424 cases of tachycardia seen at Camp Shelly it was obvious that an opportunity was afforded of classifying these possible future cases of soldier's heart before the actual onset of the trouble. In other words, an etiological factor might be determined ante rather than post, as was necessary in the English studies. Furthermore, by classifying these subjects with rapid heart it would be possible more satisfactorily to dispose of them in one of the three ways recommended by the Surgeon-General's Office, namely, accept, reject or accept conditionally. One may rightly judge, from the various hypotheses concerning the pathogenesis of soldier's heart discussed in the forepart of this paper, that there is still considerable haze as to the true factor in the production of the disorder. In spite of Lewis's masterly work there still seems, for example, a strong possibility that the thyroid may be implicated in a certain number of cases. Likewise it seems quite definitely proved that soldier's heart, while excited by an infection, is predisposed to by certain factors. The work of the English has all been done upon cases already the subject of soldier's irritable heart. There the predisposing or etiological factor had to be determined after the onset of the trouble, whereas in the present study it could be determined possibly before the trouble appeared, but as the question of the pathogenesis is still somewhat in doubt it was thought wise to classify these cases of tachycardia not from one view-point alone but to make a classification which would combine the best of the ideas as to the cause of "soldier's heart." Many of the cases of tachycardia that were seen during the course of the examinations seemed unlikely to develop "soldier's heart" and could be grouped in other classes.

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[54] Loc. cit.

[55] Épreuve d'aptitude cardique a l'effort, Presse méd., December 7, 1916, p. 563.

[56] The Circulatory Reaction to Graduated Work as a Test of the Heart's Functional Capacity, Arch. Int. Med., 1916, xvii, 363. Also, Studies of the Heart's Functional Capacity, Arch. Int. Med., 1917, xx, 829.

The following five etiological classifications of the tachycardias were made: (1) Myocardial. (2) Hyperthyroid. (3) Neurotic. (4) Nervous (emotional). (5) Toxic.

These groups will be completely discussed seriatim, giving the number of cases in each group, their findings at the time of the examinations, the reason for classifying them in such a manner and their dispositions.

The first three groups represent cases that may develop "soldier's heart," the last two represent tachycardia of mild degree in whom it is believed no such result will obtain. These last groups will be discussed in the light of the experience of others more fully than the first three groups, which have been dwelt upon from this view-point in the early part of the paper.

1. *Myocardial.* Sixty-nine cases, or 16.3 per cent., of the tachycardias were of this type. The diagnosis was based upon the history of the individual, the physical findings and the functional tests. In considering the history, and it is in the individual with this type of rapid heart that the history is most important, it was noted that a large majority of these soldiers had suffered from pneumonia some time during the preceding five years, an interesting commentary upon the deleterious effect of pneumonia upon the heart. The present history was also important. The soldier suffered from dyspnea upon slight exertion, a cough was sometimes present and there were other subjective evidences of a very moderate degree of cardiac insufficiency. The physical examination, outside of the tachycardia, usually showed but little. At times a slight enlargement of percussion dulness was noted.[57] The functional test, the response to exercise was also of great value in determining this type of tachycardia. Failure of the pulse to return to normal within two minutes was considered an evidence of myocardial weakness and was the *sine qua non* in diagnosing these cases.

The disposition of the soldier with a rapid heart, presumably the result of myocardial change of a moderate degree such as outlined above, was usually "accept," as it was felt that the gradually increasing exercises of the training period would materially benefit the heart so that he would be able to go through hardships of any type. Cases giving a history of acute rheumatic fever were rejected, as it is almost impossible to imagine the myocardium not being injured after this disease. Furthermore, Lewis found a large percentage (about 20 per cent.) of his cases of soldier's heart gave a past history of this disease.

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[57] It should be understood that frank cases of myocardial disease and cases of valvular heart disease with associated myocardial weakness were not listed in this group. These cases were diagnosed "myocarditis, chronic" and "valvular heart disease," and as such were considered. The above classification includes only those cases that are questionable. The term myocardial tachycardia is used because of the apparent slight degree of myocardial involvement. There was a history of pneumonia and there was a myocardial insufficiency, but that there was a true pathological myocarditis which could be demonstrable at autopsy could not be proved.

2. *Hyperthyroid.* Ninety-seven cases of tachycardia attributable to malfunctioning of the thyroid, or larval hyperthyroidism, were seen. Three symptoms of hyperthyroidism were considered necessary to place a man in this group. Two of these symptoms were practically constant, a pulse rate of over 130 and a fine tremor; the third symptom was either enlargement of the thyroid or well-marked vasomotor symptoms. Exophthalmos was seen only a few times. The response to the functional test was usually poor. These cases were usually fairly easy to determine. Their disposition was, excepting in the well-marked unquestionable cases, which were rejected, generally "provisionally accept," as it seemed likely that these men would probably break down under the stress of trench warfare, developing exophthalmic goitre if not soldier's heart. If upon subsequent examination the symptoms have not disappeared it would seem wise to discharge them upon a surgeon's certificate of disability. An interesting point in regard to these cases was that a large percentage of them were found in a regiment recruited in the mountains of West Virginia. In this same regiment there were also found many men with symptomless goitres.

3. *Neurotic.* In this group fell the largest number of cases, 180 (or 42.5 per cent.). These men practically all presented the following syndrome: A pulse rate of over 120; an exaggerated sinus arrhythmia, and a functional heart murmur, systolic in tone, soft and blowing, heard best over the second and third interspaces, referred upward and to the subclavian artery, and never to the axilla. In discussing the murmur systolic in time, heard over the pulmonary valve area, H. M. Raven[58] says that in his experience with a camp of over 2000 boys under nineteen, a large number of them have this murmur. It is associated with poor physique and retarded development. He suggests that in addition to the commonly accepted theory that it arises as a result of friction between the pulmonary artery and the chest wall or adjacent structures, another theory might be advanced, that it is due to a relative or actual narrowing of the pulmonary artery (congenital). In these cases D. A. H. symptoms are very common.

The term neurotic is poor but was employed because these men all had many and diverse complaints of all kinds. Their subjective symptoms were pronounced, not only symptoms referable to the heart but symptoms which were indefinite, vague and uncertain, and referable to all parts of the body. Vagal might perhaps be a more satisfactory term, as they showed usually pronounced evidences of vagus instability. The majority of these men were listed as "conditionally accept." The experience of the English has shown that men falling into this classification are unable to stand the wear and tear and stress of severe campaigning. It is from this group that will probably come the most men who will develop the irritable hearts of soldiers. Their symptoms, their vagal instability, their heart examination, their rapid pulse rate, their poor response to the functional exercise test, all these findings are characteristic of the typical case of "soldier's heart." Indeed, they might readily be said to belong to that large class mentioned by Lewis in whom symptoms appeared before enlistment and who are not truly subjects of "soldier's heart," in the sense that the soldier's life is necessary to cause "soldier's heart." Some mild infection incurred before ever seeing active warfare may so exaggerate the symptoms that the man is no longer fit for active soldiering. It would be interesting to see how well these men respond to the splendid hygiene of camp life. Probably a goodly number will be so immeasurably benefited by the exercise, outdoor life, proper food, regular hours and careful life of camp that they will be able to go through with any future assignments they might receive. In the meantime by listing them as "conditionally accept" they will be under constant observation, and should they not be materially benefited by their new environment, should be kept in this country to perform military duties less arduous than those they will meet with overseas.

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[58] British Med. Jour., August 25, 1917, p. 251.

4. *Nervous (Emotional)*. The soldiers with rapid hearts who fell into this classification presented few objective or subjective manifestations of disordered heart. The tachycardia was not excessive, rarely over 120, physical findings were negative and the response to the functional test was normal. There were only twenty-eight men referred who were listed in this group. This may seem like a surprisingly small number, but it is small because such a diagnosis was made only when the pulse rate was unduly rapid. The men with the slower pulses were listed as "heart normal." The men of this group if allowed to sit quietly for twenty or thirty minutes to watch the examinations going on, in order to do away with the nervous excitement incident to the examination, and then examine them, their hearts would be found to have normal rates.

Two opinions as to the relatively innocuousness of this type of tachycardia may be mentioned. Sir James Mackenzie[59] calls attention in his brief memorandum to medical examiners to the effects of excitement. He states that many candidates with perfectly healthy hearts suffer from excited action of the heart during examination. The heart becomes rapid but soon slows down if the candidate lies down and breathes slowly and deeply for a few minutes. Such a candidate is considered suitable for enlistment if there is a history of good functional efficiency. A. Morrison[60] is in complete accord with the idea that "the augmented and accelerated action of the emotional heart ought also to lead to few rejections."

5. *Toxic*. Thirty-six cases of tachycardia, apparently due to intoxication of some kind, are grouped here. Some of these men were suffering from tonsillitis or some other mild infection at the time of the examination. Some were smoking an excessive number of cigarettes a day—thirty to sixty. Some few were alcoholic. Some were drinking enormous quantities of coffee. All of them had a rapid heart, apparently the result of some toxin, whether bacterial or a drug. Cases of tuberculosis or other severe infection with the associated tachycardia are

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[59] The Recruit's Heart, British Med. Jour., October 16, 1915, p. 563.

[60] Ibid., October 30, 1915, p. 636.

not grouped here. Except for the rapid heart, physical examination disclosed nothing of moment. As regards effects of cigarette-smoking and alcohol there is of course considerable divergence of opinion.

Cigarette-smoking undoubtedly has the effect of increasing the heart action, but that it has any more serious effect is dubious. J. Parkinson and H. Koefid,[61] in a recent article in which the effect of cigarette-smoking is fully discussed, conclude that the smoking of a cigarette by habitual smokers raises the pulse rate, which effect is more pronounced in cases of soldier's heart; that excessive smoking is not the essential cause in most cases, but in their opinion it is an important contributory factor in the breathlessness and precordial pain of many of them. R. D. Rudolf[62] says that the excessive use of tobacco is often stated to be a cause of soldier's heart, and no doubt in many cases it is one. Lewis, however, does not lay much stress on tobacco as a cause of disordered action of the heart. In his series 5 per cent. did not smoke, and he calls attention to the fact that the same symptoms appear in soldiers who do not smoke. Likewise with alcohol, more than half of his cases were not consumers of alcoholic drinks and many of them showed actual distaste for it. Parkinson[63] found in his series of 40 cases that about half either smoked a pipe or were very light smokers, and that in regard to alcohol only 3 had been heavy drinkers. E. K. Tullidge[64] in his experience in Austrian service says that in a number of cases the disturbance could be traced directly to the excessive use of tobacco.

Fourteen cases of rapid hearts were seen which fell into no category. It was apparently impossible to group them satisfactorily.

SUMMARY. "Soldier's heart" is discussed in the light of the experience of our allies. The importance of tachycardia as a prominent and important objective symptom in the examination of the recruit is called attention to and a classification for cases of tachycardia is suggested.

NECROPSY SERVICE IN A MILITARY HOSPITAL IN THE FIELD.

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THE following report is offered not because of its statistical value but because it represents fairly well the type of work a pathologist sees in a base hospital in France and because it offers certain suggestions as to the sequences and treatment of war wounds. It represents eight months' service in a base hospital in France of about 1250 beds. The total number of necropsies is 87, which represents nearly all the deaths that occurred in the period mentioned. The necropsies were performed under fairly satisfactory conditions, and, as a rule, a few hours after death. There were no limits as to the extent of the examination,

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[61] The Immediate Effect of Cigarette Smoking on Healthy Men and on Cases of Soldier's Heart, Lancet, London, August 18, 1917, p. 232.

[62] Canadian Med. Assn. Jour., 1916, vi, 796.

[63] Loc. cit.

[64] The Heart of the Recruit and the Soldier, Military Surgeon, 1917, xl, 24.